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DOMESTIC PREPAREDNESS PROGRAM: TESTING OF MIRAN SapphIRe PORTABLE AMBIENT AIR ANALYZERS AGAINST CHEMICAL WARFARE AGENTS SUMMARY REPORT

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This report characterizes the chemical warfare (CW) agent detection potential of the commercially available MIRAN SapphIRe Portable Ambient Air Analyzers. These detectors were tested against HD, GB, and GA vapor at various conditions. This report is intended to provide the emergency responders concerned with CW agent detection an overview of the detection capabilities of these detectors.

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PREFACE

The work described in this report was authorized under the Expert Assistance (Equipment Test) Program for the U.S. Army Soldier and Biological Chemical Command, Program Director for Domestic Preparedness. This work was started in April 1999 and completed in July 1999.

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Dr. Edward T. Zellers, University of Michigan, School of Public Health, Ann Arbor, MI

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1. INTRODUCTION

The Department of Defense (DOD) formed the Domestic Preparedness (DP) Program in 1996 in response to Public Law 104-201. One of the objectives is to enhance federal, state and local capabilities to respond to Nuclear, Biological and Chemical (NBC) terrorism incidents. Emergency responders who encounter a contaminated or potentially contaminated area must survey the area for the presence of toxic or explosive vapors. Presently, the vapor detectors commonly used are not designed to detect and identify chemical warfare (CW) agents. Little data are available concerning the ability of these commonly used, commercially available detection devices to detect CW agents. Under the Domestic Preparedness (DP) Expert Assistance (Test Equipment) Program, the U.S. Army Soldier and Biological Chemical Command (SBCCOM) established a program to address this need. The Design Evaluation Laboratory (DEL) at Aberdeen Proving Ground, Edgewood, Maryland, performed the detector testing. DEL is tasked with providing the necessary information to aid authorities in the selection of detection equipment applicable to their needs.

Several detectors were evaluated and reported during Phase 1 testing in 1998. Phase 2 testing in 1999 continues the evaluation of detectors including the MIRAN SapphIRe Portable Ambient Air Analyzer, MSA tubes, the APD2000, and the M90-D1-C Chemical Warfare Agent Detector.

2. OBJECTIVE

The objective of this test is to provide emergency responders concerned with CW agent detection an overview of the capabilities of the MIRAN SapphIRe portable ambient air analyzer to detect chemical warfare agent vapors. This summary report is one of several reports on the Phase 2 evaluations of detectors conducted during 1999.

3. SCOPE

The scope of this evaluation is to characterize the CW agent vapor detection capability of the MIRAN detector. The agents used included Tabun (GA), Sarin (GB), and Mustard (HD). These were chosen as representative CW agents because they are believed to be the most likely threats. Test procedures followed those described in the Phase 1 Test Report[1]. The test concept was as follows:

a. For each selected CW agent, determine the minimum concentration levels (Minimum Detectable Level, MDL) where repeatable detection readings are achieved. The military Joint Services Operational Requirements (JSOR) serves as a guide for detection sensitivity objectives.

b. Investigate the effects of humidity and temperature on detection response.

c. Use results to establish response curves for each agent.

d. Observe the effects of potential interfering vapors upon detection performance, both in the laboratory and in the field.

4. EQUIPMENT AND TEST PROCEDURES

4.1 DETECTOR DESCRIPTION

The Foxboro Company manufactures the MIRAN SapphIRe portable ambient air analyzer. The MIRAN SapphIRe is a man portable infrared (IR) spectrophotometer. The intensity of the absorbed infrared energy of the air sample in the cell is displayed on the detector panel in Absorbance Units (AU). The optimum detection wavelength for the compound of interest must be known and manually entered into the MIRAN's memory to enable detection of that compound. The factory usually provides the appropriate wavelength to be used for detection of a specific substance. However, because of the lack of accessibility to the CW agents, the manufacturer was unable to test and assign the applicable wavelengths for the agents of interest. Therefore, prior to this evaluation, DEL in conjunction with a Foxboro representative challenged these detectors with HD, GB and GA vapor to select the appropriate wavelengths to enable detection of these agents. The Foxboro representative then stored these wavelength values into the detector library. The wavelengths selected for GB, GA and HD are 9.9, 9.7, and 13.9 microns, respectively. The MIRAN was operated in its multi-gas detection mode that allows the detector to indicate the absorption responses at the three wavelengths simultaneously.

Operating procedures were followed according to the manufacturer's Instruction Manual[2] where applicable. Conclusions are based solely on the results observed during this testing. Aspects of the detectors, other than those described in the scope, were not investigated.

Figure 1 is a digital photograph of the MIRAN SapphIRe. Three units were purchased for the evaluation and designated according to serial numbers as MIRAN 501, 503, and 504. During testing, 110 Volt AC adapters were used to ensure that detector performance would not be affected by battery condition.

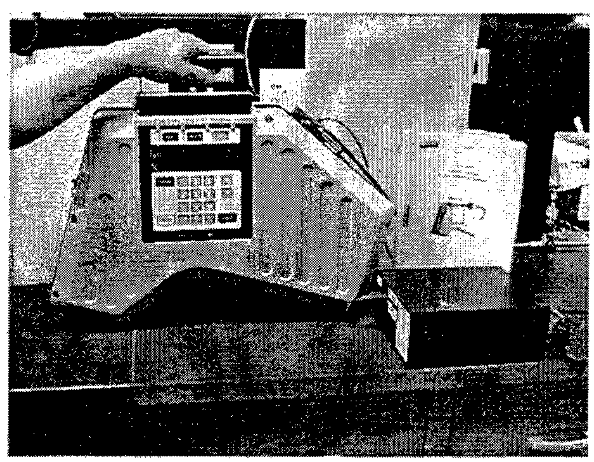

Figure 1. MIRAN SapphIRe

The MIRAN can operate at different path lengths. For this evaluation, the longest path length (12.5 meters) was used to assess the highest possible sensitivity of the instrument toward detection of the CW agent vapors.

The internal pump of the MIRAN normally draws 14 liters per minute. Unfortunately, the existing agent generator cannot produce the required volume without major investment for different equipment. Therefore, the MIRAN internal pump was switched off and 3 to 4 liters per minute of the agent vapor/conditioning air mixture were pumped into the detector from the agent generator. The procedure is considered acceptable for the evaluation of the respective sensitivities to the CW agents because of the nature of IR detection. The sensitivity of the instrument is based on the absorption of infrared light as it passes through the vapor concentration within the detector cell. Once the sample cell is filled with a certain concentration of generated CW agent vapor, the absorbance value will be the same regardless of how the cell is filled. Since the MIRAN is able to pull 14 liters per minute under normal operating conditions, the cell would fill or clear quicker than at the slower 3 liter per minute rate used during testing. Therefore, the stable detection reading would be observed sooner at the higher flow rate. A 5 minute sensing time was used to ensure that the sample cell was completely purged and filled with the test vapor.

Given the above reasoning, two MIRAN detectors were connected in series during testing. This enabled the detectors to be tested simultaneously. Concentration readings taken at the inlet of the first detector and the outlet of the next detector proved to be within 10% of each other which corresponded with the detector signals.

The MIRAN is equipped with an external particulate filter to prevent dirt from entering its internal plumbing. It also has a chemical filter that is interchangeable with the particulate filter. The chemical filter is used to zero the instrument as well as to provide clean air to the instrument in a contaminated environment. The filter is connected to the instrument using a corrugated plastic probe. The particulate filter was used during the field tests only. It was not used in the laboratory under clean environment except that the filter was tested for agent vapor passage. Results indicated the probe and the particulate filter did not adversely affect the agent detection sensitivity.

4.2 CALIBRATION

Each detector was allowed to stabilize thoroughly before initiating the calibration procedures. Calibrations were performed daily per instructions using the filters provided with the detector. Calibration involves allowing the detector to fill with conditioned, low-humidity air (zero air) using the chemical (zero air) filter during the zeroing process. Then the particulate filter is placed on the detector and the MIRAN is allowed to fill with conditioned air to observe the background readings at the specified wavelengths. The detector display prompts the user through the procedures and the analysis menu appears after the calibration is completed.

4.3 AGENT CHALLENGE

The agent challenges were conducted using the Multi-Purpose Chemical Agent Vapor Generation System[3] with zero air and Chemical Agent Standard Analytical Reference Material

(CASARM) grade CW agents where available. The vapor generator permits preconditioning of a detector with humidity and temperature air before challenging it with similarly conditioned air containing the CW agent.

Agent testing followed successful detector calibration. First, conditioned air at the desired temperature and humidity from the vapor generator system is sampled by the MIRAN for approximately five minutes to establish the stable "background reading" of the detector. This background reading (baseline) at the testing condition is required to establish the net detector response from the agent challenge reading. The net detector reading is the challenge reading minus the background reading.

Agent challenge begins when the vapor generation system's solenoids are energized to switch the air streams from conditioned air only to similarly conditioned air containing the agent. Each detector test was repeated three times under each condition. The agent challenge time allowed was 5 minutes to reach a stable detector response. The detector response in absorbance units was observed and recorded at the end of each minute during the agent challenge. Occasionally, a longer exposure (~10 minutes) reading was recorded to confirm that the 5 minute reading was sufficient time for complete purging of the sample cell for the detector response. Also, the times for clear down back to the baseline after the agent challenge were noted. Subsequent challenge occurred when the baseline returned approximately to the initial baseline value.

4.4 AGENT VAPOR QUANTIFICATION

The generated agent vapor concentrations were analyzed independently and reported in units of mg/m^3. The vapor concentrations were converted into parts per million (ppm) units and all values and times were recorded in the data spreadsheets.

The generated agent vapor was quantified by manual sample collection methodology[4] using the Miniature Continuous Air Monitoring System (MINICAMS®) manufactured by O. I. Analytical, Inc., Birmingham, Alabama. The MINICAMS® is equipped with a flame photometric detector (FPD). This system normally monitors air by collection through sample lines and subsequently adsorbing the CW agent onto the solid sorbent contained in a glass tube referred to as the pre-concentrator tube (PCT). The PCT is located after the MINICAMS® inlet. Here the concentrated sample is periodically heat desorbed into a gas chromatographic capillary column for subsequent separation, identification, and quantification.

For manual sample collection, the PCT was removed from the MINICAMS® during the sample cycle and connected to a vacuum pump to draw the vapor sample from the agent generator. The PCT was then re-inserted into the MINICAMS® for analysis. This "manual sample collection" procedure eliminates potential loss of sample through sampling lines and the inlet assembly in order to use the MINICAMS® as an analytical instrument. The calibration of the MINICAMS® is performed daily using the appropriate standards for the agent of interest.

4.5 DETECTOR AGENT SENSITIVITY

In laboratory tests, two of the MIRAN detectors, 501 and 504, were each tested with the agents GA, GB and HD at different concentration levels at ambient temperatures (~20°C) and low relative humidity (<5%) in an attempt to determine the minimum detectable level (MDL) and establish response curves. The detectors were also tested at temperature extremes based on the Instruction Manual's performance criteria. The MIRAN was evaluated at 5°C and 40°C, and at the additional relative humidity conditions of 50% and 90% to observe temperature and humidity effects. An environmental temperature chamber was used for high and low temperature testing.

Comparative tests of MIRAN response with and without the detector probe yielded similar results. The particulate filter was not used in the clean laboratory environment.

4.6 FIELD INTERFERENCE TESTS

After the agent sensitivity tests, two of the units, MIRAN 503 and MIRAN 504, were qualitatively tested outdoors. Absorbance responses were gathered for each respective wavelength in the presence of common potential interferents such as the vapors from gasoline, diesel fuel, jet propulsion fuel (JP8), kerosene, AFFF liquid (Aqueous Film Forming Foam used for fire fighting), household chlorine bleach and insect repellent. Vapor from a 10% HTH slurry (a chlorinating decontaminant for CW agents), engine exhausts, burning fuels and other burning materials were also tested.

The field tests were conducted outdoors at M-Field of the Edgewood Area of Aberdeen Proving Ground in July 1999. The detectors were placed at various distances downwind of the open containers, truck engine exhausts or fires producing smoke plumes. Distances from the source varied according to the prevailing conditions to obtain reasonable exposures for each detector, for example, 1-2 meters for fumes and 2-5 meters for smokes. The objective was to assess the ability of the detectors to withstand outdoor environments and to resist 'false positive' indications when exposed to the selected 'potential interference' substances.

The MIRAN units were tested in the multi-gas mode using its internal pump at 14 liters per minute sampling rate. The units were tested with the particulate filter attached. The multi-gas detection mode yields responses at the three chosen wavelengths corresponding to GA, GB, and HD. This mode gives fast results for all three agents simultaneously by using the corresponding wavelength to yield the Absorbance Units. Testing continued with the next interferent when the detector display baseline reading stabilized. Testing included three exposures of the units to each interferent unless the interferent showed an obvious blackening of the detector's filter. Then, to prevent excessive contamination, the units were only exposed once or twice.

4.7 LABORATORY INTERFERENCE

These tests were designed to assess the detector response to vapor from representative substances, and to show the CW agent detection capability of the units in the presence of the potential interference vapors from AFFF and diesel fuel. The interferents were chosen based on the likelihood of their presence during an emergency response by first responders.

The detectors were screened against "1% concentrations" of gasoline, JP8 (jet fuel), diesel fuel, household chlorine bleach, floor wax, AFFF (Aqueous Film Forming Foam for fire fighting), Spray 9 cleaner, Windex, and 25 PPM ammonia to observe potential interference with the detection reaction process. If the detector gave false positive results at 1%, they were tested against an "0.1% concentration" of each interferent. To prepare the interferent test gas mixture, dry (<5% RH) air at 20°C was saturated with interferent vapor by passing it through the interferent liquid in a bubbler or by sweeping it over the liquid contained in a tube. Thirty milliliters of this vapor saturated air was then diluted to three liters of the conditioned air to produce the "1% concentration" of interferent. In the same manner, a 0.1% concentration of interferent was produced using three milliliters of vapor saturated air diluted to 3 liters of generator air to further test the detectors if they false alarmed at the higher concentration. The 25 ppm ammonia was derived by proper dilution of the 1% NH_3 vapor from an analyzed compressed gas cylinder. The 25 ppm ammonia concentration was chosen as representative of possible occurrences in typical CW protective shelters.

The CW agent detection capability of the MIRAN detectors in the presence of the potential interference vapors from AFFF and diesel fuel was assessed. The test mixture was prepared similarly to produce the 1% or 0.1% 'concentrations' of potential interference vapor but the prescribed concentration of CW agent from the agent generator was included in the test exposures.

For the tests utilizing CW agent, the interferent test gas mixture was prepared by using dry air at 20°C that was saturated with interferent vapor by passing it through the diesel fuel or AFFF liquid in a bubbler. Thirty milliliters of this vapor saturated air was then diluted to three liters with the (20°C, <5% RH) conditioned air containing a prescribed concentration of CW agent from the agent generator to produce the "1% concentration" of interferent. The two MIRAN detectors were tested three times with test air containing CW agent plus interferent. The detection responses with conditioned air containing HD, GA or GB in the presence of 1% by volume of air saturated with diesel fuel vapor and AFFF vapor were recorded.

5. RESULTS AND DISCUSSION

5.1 MINIMUM DETECTABLE LEVELS

The minimum detectable levels (MDL) for the detectors (MIRAN 501 and MIRAN 504) are shown in Table 1 for each agent at ambient temperatures and low relative humidity (<5%RH). The <5% RH condition was used to establish the MDL because the detectors were zeroed and calibrated using zero (dry) air. These MDL values were selected based on detector readings that were consistent and greater than the highest baseline reading observed in the laboratory during the sensitivity testing. This enables a detector reading to be distinguished from background variations.

The MDL concentrations are expressed in mg/m^3 and the equivalent parts per million (ppm) values are also shown. The current military requirements for CW agent detection (Joint Service Operational Requirements [JSOR] for CW agent sensitivity for point detection alarms) and the Army's established values for Immediate Danger to Life or Health (IDLH) and Airborne Exposure Limit (AEL) are also listed as references to compare the detector's performance.

When compared to the JSOR and IDLH values, the MDLs of the MIRAN units for the nerve agents (GA and GB) are approximately an order of magnitude higher. The MIRAN will not detect nerve agents at concentrations as low as the current military JSOR, IDLH and AEL values. However, the blister agent HD was detected at concentrations of 2.54 mg/m^3 that is near the JSOR level of 2 mg/m^3. Army regulation AR 385-61 does not establish an IDLH for HD due to concerns over carcinogenicity. HD was not detected to its AEL value.

Table 1. Minimum Detectable Level (MDL) for HD, GA, and GB at Ambient Temperatures and <5% Relative Humidity

AGENT	Concentration in milligrams per cubic meter, mg/m^3, With parts per million values in parenthesis (ppm)			
	MIRAN 501 & 504	JSOR*	IDLH**	AEL***
HD	2.54 (0.384)	2.0 (0.300)	N/A	0.003 (0.0005)
GA	1.30 (0.193)	0.1 (0.017)	0.2 (0.03)	0.0001 (0.000015)
GB	0.83 (0.142)	0.1 (0.017)	0.2 (0.03)	0.0001 (0.000015)

* Joint Service Operational Requirements for point sampling detectors.
** Immediate Danger to Life or Health values from AR 385-61 to determine level of CW protection. Personnel must wear full ensemble with SCBA for operations or full face piece respirator for escape.
*** Airborne Exposure Limit values from AR 385-61 to determine masking requirements. Personnel can operate for up to 8 hours unmasked.

5.2 DETECTOR AGENT SENSITIVITY

The results of the MIRAN responses to the CW agents at the various test conditions are presented in Table 2. The average of three exposures for each condition is listed for each detector. Response curves were produced from these results. The testing was conducted at ambient temperatures (21-26°C), and at the temperature extremes of 5°C and 40°C, and included the relative humidity conditions of 0, 50 and 90%. The intensity of the absorbed infrared energy is displayed on the detector panel in Absorbance Units (AU). Response values represent the net detector response in absorbance units (detector reading after exposure minus the background reading before exposure).

The concentration response curves are shown in Figure 2 for HD, GA and GB. The response curve values represent the Table 2 results of multiple challenges at ambient temperatures with agent concentrations between 0.8 and 18 mg/m^3. Each set of curves shows the responses of the CW agents tested at 0%, 50%, and 90% relative humidity. A linear relationship between agent concentration and detector response in absorbance units was observed down to the minimum detectable level for each agent. It appears that high humidity caused a decrease in net detector response. Also, it was noted that the MIRAN baseline response seems to be affected by relative humidity changes. The response curves show the consistent and reliable increase in response of the MIRAN units to increase in agent concentration in the range of concentrations tested.

Table 2. Average Response Values for the MIRAN 501 and MIRAN 504

Agent	Average Temperature, °C	Relative Humidity, % RH	Agent Concentration mg/m³	Agent Concentration ppm	MIRAN 501 Absorbance Units (AU)	MIRAN 504 Absorbance Units (AU)
HD	20	<5	**2.54**	0.384	0.0020	0.0017
HD	20	<5	**8.36**	1.264	0.0045	0.0035
HD	20	<5	**13.94**	2.107	0.0065	0.0051
HD	20	50	**6.0**	0.907	0.0032	0.0022
HD	20	50	**9.0**	1.361	0.0053	0.0038
HD	20	>90	**3.47**	0.525	0.0011	0.0005
HD	20	>90	**10.4**	1.572	0.0044	0.0032
HD	5	0	**6.95**	0.997	0.0042	0.0030
HD	40	0	**5.53**	0.893	0.0047	0.0035
GA	20	<5	**1.30**	0.193	0.0038	0.0034
GA	20	<5	**2.0**	0.297	0.0049	0.0040
GA	20	<5	**2.5**	0.371	0.0066	0.0057
GA	20	<5	**4.51**	0.669	0.0139	0.0118
GA	20	<5	**13.03**	1.933	0.0360	0.0301
GA	20	50	**5.16**	0.766	0.0092	0.0080
GA	20	50	**10.17**	1.509	0.0248	0.0215
GA	20	>90	**4.66**	0.691	0.0109	0.0096
GA	20	>90	**16.94**	2.513	0.0383	0.0350
GA	5	0	**3.0**	0.422	0.0119	0.0098
GA	40	0	**10.45**	1.656	0.0259	0.0235
GB	20	<5	**0.83**	0.142	0.0031	0.0032
GB	20	<5	**2.61**	0.448	0.0084	0.0082
GB	20	<5	**8.15**	1.399	0.0245	0.0246
GB	20	<5	**17.96**	3.083	0.0542	0.0546
GB	20	50	**2.72**	0.467	0.0095	0.0093
GB	20	50	**9.85**	1.691	0.0304	0.0309
GB	20	50	**17.5**	3.004	0.0509	0.0512
GB	20	>90	**2.67**	0.458	0.0066	0.0068
GB	20	>90	**8.90**	1.528	0.0210	0.0206
GB	20	>90	**15.44**	2.651	0.0353	0.0351
GB	5	0	**2.51**	0.409	0.0139	0.0142
GB	40	0	**1.25**	0.229	0.0073	0.0072

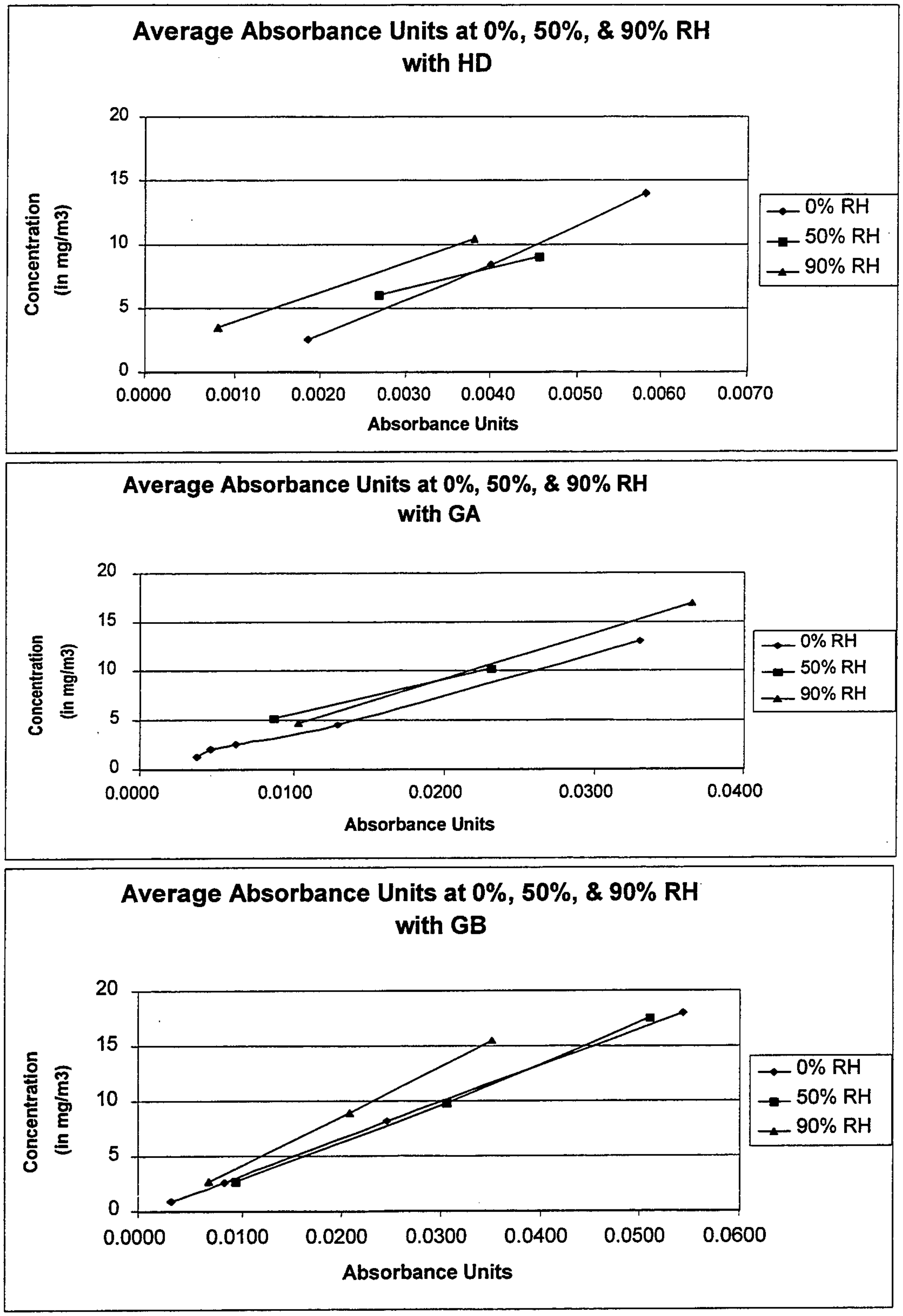

Figure 2. MIRAN Concentration Response Curves at 0, 50, and 90% RH

5.3 FIELD INTERFERENCE

The ranges of detector readings recorded during the field exposures to interference vapors are presented in Table 3. It should be noted that the concentration of the interferent reaching the detectors fluctuated with wind direction and velocity. Therefore, the detector readings should only be considered an indication of the qualitative effect of the interferents on the detectors. To avoid excessive contamination of the detectors, some of the burning material tests were not repeated three times. No CW agents were used in these field tests.

The ambient temperature and relative humidity levels during these tests were in the range of 26-36°C and 53-91% RH, with gentle wind. The detector readings in Table 3 represent the range of the net responses after baseline subtraction. Baseline readings were taken in ambient air away from the interferent plume before each trial. Negative values were observed for some conditions. The baseline readings drifted continually throughout each day of testing indicating that the detectors were contaminated from the repeated exposures. Time restraints made it impractical to wait for absolute clear downs.

Table 3. Field Interference Testing Summary

Interferent	MIRAN 503 and 504 Field Test Response Ranges in Absorbance Units (AU)			
	Baselines (AU) for GA, GB & HD	Net AU for GA	Net AU for GB	Net AU for HD
Gasoline Exhaust, Idle	0.0063 to 0.0176	0.0008 to 0.0013	0.0007 to 0.0014	0.0043 to 0.0334
Gasoline Exhaust, Revved	0.0105 to 0.0273	0.0011 to 0.0026	0.0010 to 0.0019	0.0280 to 0.1584
Diesel Exhaust, Idle	0.0206 to 0.0331	0.0003 to 0.0027	0.0002 to 0.0028	0.0012 to 0.0555
Diesel Exhaust, Revved	0.0225 to 0.0348	0.0003 to 0.0039	0.0003 to 0.00039	-0.0001 to 0.0791
Kerosene Vapor	0.0250 to 0.0377	0.0004 to 0.0011	0.0005 to 0.0011	0.0005 to 0.0013
Kerosene on Fire	-0.0059 to 0.0406	-0.0023 to 0.0019	-0.0022 to 0.0020	0.0045 to 0.0194
JP8 Vapor	-0.0057 to 0.0028	-0.0006 to 0.0078	-0.0007 to 0.0005	-0.0004 to 0.0013
Burning JP8 Smoke	0.0033 to 0.0153	0.0004 to 0.0006	0.0006 to 0.0007	0.0158 to 0.0161
Burning Gasoline Smoke	0.0039 to 0.0159	0.0010 to 0.0013	0.0010 to 0.0014	0.0174 to 0.0221
Burning Diesel Smoke	0.0029 to 0.0157	0.0000 to 0.0009	-0.0001 to 0.0010	0.0084 to 0.0182
AFFF Vapor	-0.0027 to 0.0106	-0.0001 to 0.0002	0.0000 to 0.0001	-0.0002 to 0.0005
Insect Repellent	0.0008 to 0.0138	0.0005 to 0.0013	0.0012 to 0.0012	0.0015 to 0.0015
Diesel Vapor	-0.0079 to 0.0046	-0.0005 to 0.0004	-0.0006 to 0.0004	-0.0008 to 0.0006
Gasoline Vapor	-0.0073 to 0.0064	0.0012 to 0.0050	0.0011 to 0.0060	0.0014 to 0.0068
HTH Vapor	-0.0040 to 0.0102	0.0001 to 0.0003	0.0001 to 0.0003	0.0002 to 0.0006
Bleach Vapor	-0.0060 to 0.0090	0.0001 to 0.0008	0.0002 to 0.0009	0.0003 to 0.0008
Burning Cardboard	-0.0085 to 0.0018	0.0049 to 0.0052	0.0046 to 0.0050	0.0291 to 0.0446
Burning Cotton	-0.0087 to 0.0003	0.0014 to 0.0021	0.0015 to 0.0022	0.0047 to 0.0112
Burning Wood Fire Smoke	-0.0057 to 0.0010	0.0025 to 0.0027	0.0022 to 0.0024	0.0130 to 0.0253
Doused Wood Fire Smoke	-0.0027 to 0.0134	0.0009 to 0.0013	0.0009 to 0.0015	0.0007 to 0.0039
Burning Rubber	-0.0021 to 0.0123	0.0010 to 0.0017	0.0010 to 0.0016	-0.0003 to 0.0043

Most interferents showed at least a slight additive detector response to the already high baseline readings. The slight added response could not be construed as chemical agent detected given the already high baseline readings. The usefulness of employing these detectors in an unknown environment is limited.

Post field tests against HD and GA, in the laboratory, showed the MIRAN detectors to have no residual effects from the field tests. Response values for detecting the agents were comparable to those measured previously.

5.4 LABORATORY INTERFERENCE TESTS

Table 4 shows the results of testing the MIRAN detectors with conditioned air containing HD, GB and GA plus 1% by volume of 20°C air saturated with diesel or AFFF vapor. Net agent detection responses are comparable to the agent sensitivities test results even in the presence of these interferents. Neither interferent affected the CW agent detection capability of the MIRAN.

Table 4. Results of Laboratory Interference Tests with Agents

Interferent	Agent	Concentration mg/m3	Range of Net Detector Readings, AU	
			Interferent Without Agent	Interferent With Agent
Diesel Vapor, 1% of Saturation	HD	8.7	0 to 0.0004	0.0038 to 0.0056
	GB	7.8	0.0003	0.0248 to 0.0252
	GA	8.3	-0.0001 to 0.0000	0.0081 to 0.0095
AFFF Vapor, 1% of Saturation	HD	9.6	-0.0002 to 0.0003	0.0034 to 0.0050
	GB	9.3	0.0003	0.0246 to 0.0250
	GA	10.5	0.0000	0.0088 to 0.0100

The MIRAN was also tested against other potential interferents in the laboratory setting, without CW agents, using the multi-gas mode. This allowed observation of the potential interference responses for the HD, GB and GA wavelengths, simultaneously. Laboratory screening of potential interference is summarized in Table 5. These tests were conducted without using the CW agents in order to supplement the field interference testing, under a more controlled concentration.

If a response was seen at the 1% saturation level, the interferent was reduced to 0.1% saturation and tested again. Most interferents tested yielded at least a small interference response either at the nerve or blister wavelength, even at the 0.1% level. Table 5 is a summary of the net response ranges observed during exposure of the MIRAN to the interferent substances.

Table 5. Laboratory Interference Testing Summary

Interferent Only - No Agent Present	MIRAN 501 and 504 Lab Test Response Ranges in Absorbance Units (AU)			
	Baselines (AU) for GA, GB & HD	Net AU for GA Response	Net AU for GB Response	Net AU for HD Response
1% Diesel Vapor	-0.0058 to 0.0004	No Response	0.0003	0.0000 to 0.0004
1% AFFF Vapor	-0.0053 to 0.0017	No Response	0.0003	-0.0002 to 0.0003
1% Gasoline Vapor	-0.0050 to 0.0015	0.0775 to 0.0804	0.1005 to 0.1054	0.1177 to 0.1193
0.1% Gasoline Vapor	-0.0025 to 0.0018	0.0008 to 0.0010	0.0011	0.0012 to 0.0013
1% Bleach Vapor	-0.0026 to 0.0039	0.0004	0.0004 to 0.0006	0.0004 to 0.0005
1% Spray 9 Vapor	-0.0010 to 0.0049	0.0035 to 0.0037	0.0009 to 0.0018	0.0002 to 0.0003
0.1% Spray 9 Vapor	-0.0006 to 0.0045	0.0005	0.0002 to 0.0003	0.0001 to 0.0002
1% Windex Vapor	-0.0002 to 0.0052	0.0077 to 0.0082	0.0028 to 0.0034	0.0002 to 0.0006

Table 5. Laboratory Interference Testing Summary (Continued)

Interferent Only - No Agent Present	MIRAN 501 and 504 Lab Test Response Ranges in Absorbance Units (AU)			
	Baselines (AU) for GA, GB & HD	Net AU for GA Response	Net AU for GB Response	Net AU for HD Response
0.1% Windex Vapor	0.0000 to 0.0047	0.0005 to 0.0007	0.0003	0.0000 to 0.0002
1% Floor Wax Vapor	0.0000 to 0.0049	0.0009 to 0.0009	0.0006	-0.0001 to 0.0001
1% JP8 Vapor	-0.0015 to 0.0062	0.0005 to 0.0006	0.0004 to 0.0006	0.0007 to 0.0008
25 ppm NH4 Vapor	-0.0018 to 0.0060	0.0077 to 0.0091	0.0056 to 0.0070	-0.0005 to -0.0001

6. CONCLUSIONS

Results of CW agent challenges to the MIRAN SapphIRe portable ambient air analyzer showed the detectors are not sensitive enough to provide sufficient warning for the safety of first responders. Civilian first responders and HAZMAT personnel use Immediate Danger to Life or Health (IDLH) values to determine levels of protection selection during consequence management of an incident. Army Regulation (AR) 385-61 provides IDLH and AEL values for GA/GB, and an AEL value for HD. AR 385-61 does not establish an IDLH for HD due to concerns over carcinogenicity.

The MIRAN detectors, with MDLs determined at 0.83 mg/m^3 for GB, 1.3 mg/m^3 for GA, and 2.5 mg/m^3 for HD, were unable detect to the IDLH or AEL values for GA and GB, nor the HD AEL value. When compared to the JSOR requirements for point detectors, the MDLs of the MIRAN units for the nerve agents (GA and GB) are approximately an order of magnitude higher than the 0.1 mg/m^3 military requirement. The blister agent HD was detected at 2.54 mg/m^3, which is nearer but still higher than the current military requirement of 2 mg/m^3.

The results, however, were consistent when above the minimum detectable levels in the laboratory environment. The CW agent detection performance was reliable as evidenced by the response curves constructed from the results of CW agent laboratory testing. However, agent detection capability can only be associated in the laboratory-controlled environment where the agent presence is known.

Interference tests results, especially during the field trials, suggest that the MIRAN, in its current configuration, cannot be used for CW agent detection in the field. During the field tests, the background AU readings with or without the presence of interferents were significantly higher than baseline readings in the laboratory. In fact, those readings exceeded most of the AU response readings observed during the agent challenges in the laboratory. These high baseline readings negate the usefulness of the data obtained for agent detection sensitivity. Simply, there is no way to distinguish the AU readings as a detection of chemical agent vapor or other contaminants when operated in an unknown environment. The usefulness of this type of detector for first responders in unknown situations is considered minimal.

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